Imperial College London

Inter-annual variability and long-term change inferred from IASI and IRIS

Helen Brindley and Richard Bantges
Space and Atmospheric Physics Group

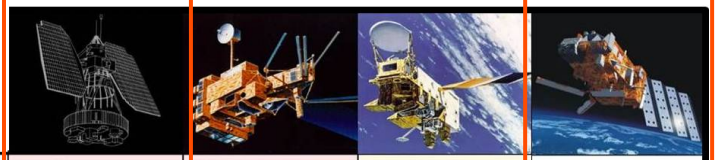
Status of CLARREO ST activities at Imperial

- Christopher Dancel left in July 2013
- Funding agreed by NCEO until April 2014 (thanks Rosemary and Bruce!)
- Richard Bantges currently working (almost) full time on the project

Re-scoped project aims

- What is the variability seen in observed radiance spectra? Robustness of ‘clear-sky’ and ‘all-sky’ change signals?

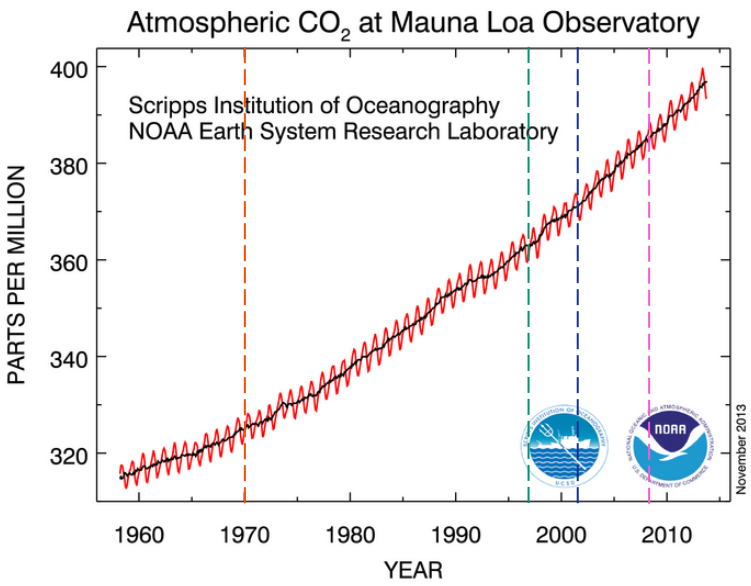
- How does this compare to the variability seen in model predictions, and what can this tell us about the representation of the processes driving this variability?

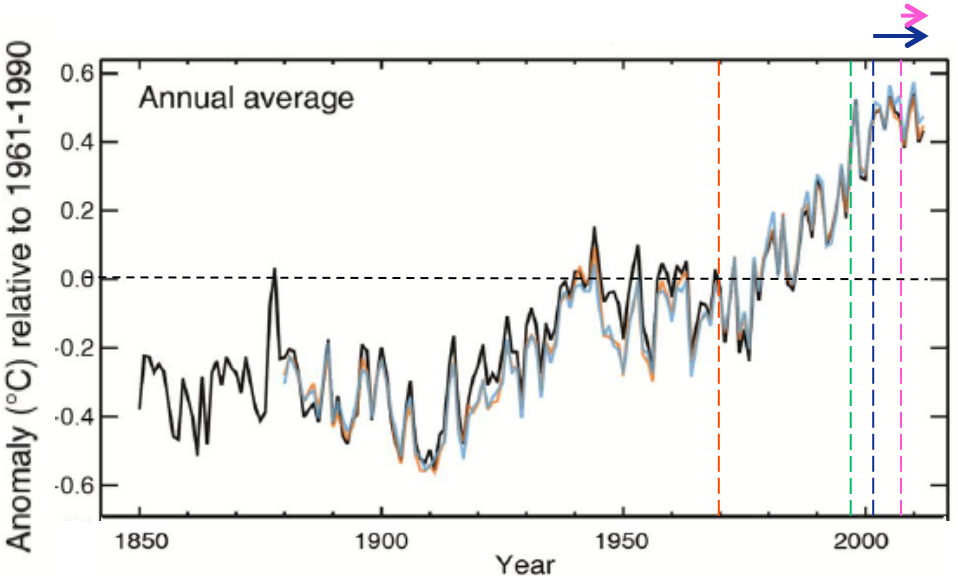


Instrument	IRIS	IMG	AIRS	IASI
Satellite	Nimbus 4	ADEOS	AQUA	METOP-A
Spectro-meter type	FTS	FTS	grating spectrometer	FTS
Data available	Apr 1970 – Jan 1971	Oct 1996 – Jun 1997	2002 - present	2007 - present
Spectral coverage (cm^{-1})	400 – 1600 cm^{-1} continuous	715 – 3030 cm^{-1} 3 bands	650 – 2700 cm^{-1} 2378 bands	645 – 2760 cm^{-1} 3 bands
Spectral resolution	2.8 cm^{-1}	0.1 cm^{-1}	0.4–1.0 cm^{-1}	0.5 cm^{-1}
Footprint (nadir)	95 km diameter	8km x 8km	13 km diameter	12 km diameter

Use IASI to give a measure of variability, compare to IRIS for longer term change

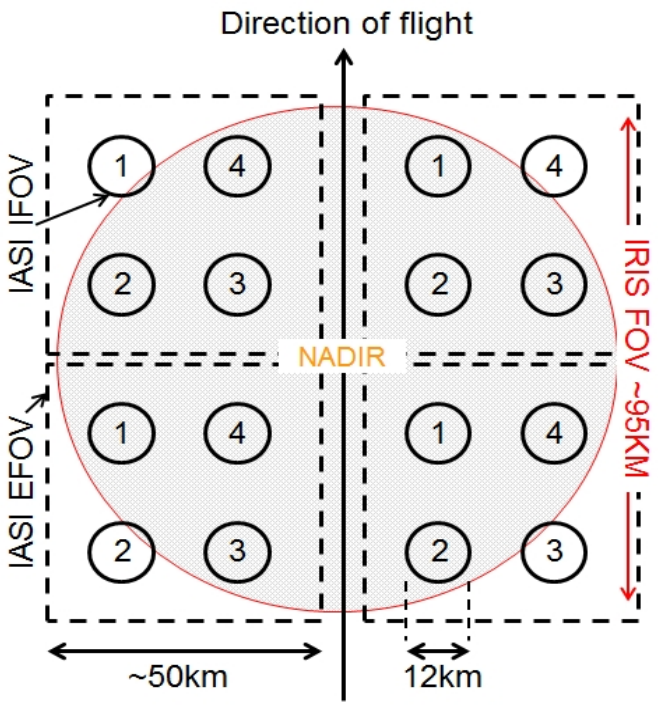
Potential to identify forcings and feedbacks in the observations?





Obtain consistency in spatial/spectral sampling

Spatial consistency: average 16 IASI IFOV footprints



Spectral consistency

IRIS

Pad each spectrum to 0-2000 cm^{-1} at original sampling interval

↓

FT padded spectrum

↓

FT and output at 0.1 cm^{-1} sampling interval (~ 2.8 cm^{-1} resolution)

IASI

Pad and truncate average spectra to 0-2000 cm^{-1} at original sampling interval

↓

FT, remove IASI apodisation function & apply varying length Hamming window

↓

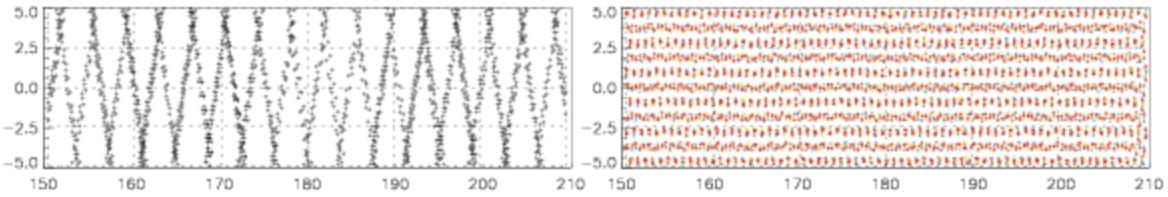
FT output at 0.1 cm^{-1} sampling interval (~ 2.8 cm^{-1} resolution)

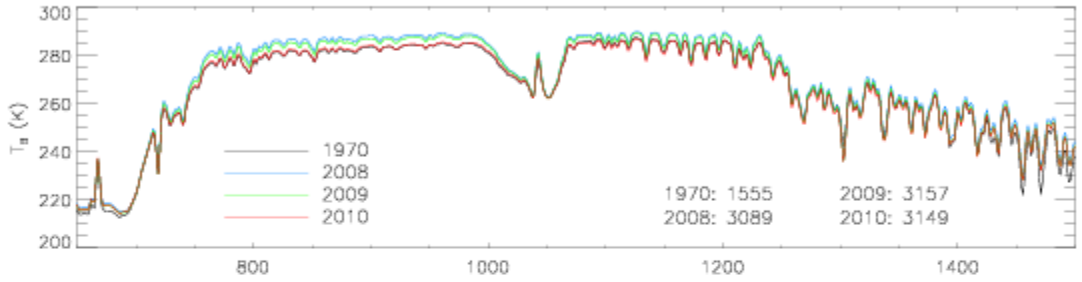
↓

Apply remaining FOV correction factor

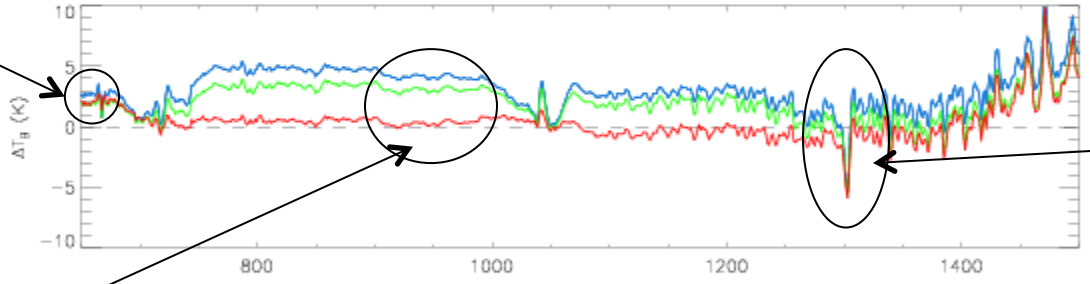
Last time:
All-sky preliminary analysis: 3 years, limited areas

West Pacific XAM



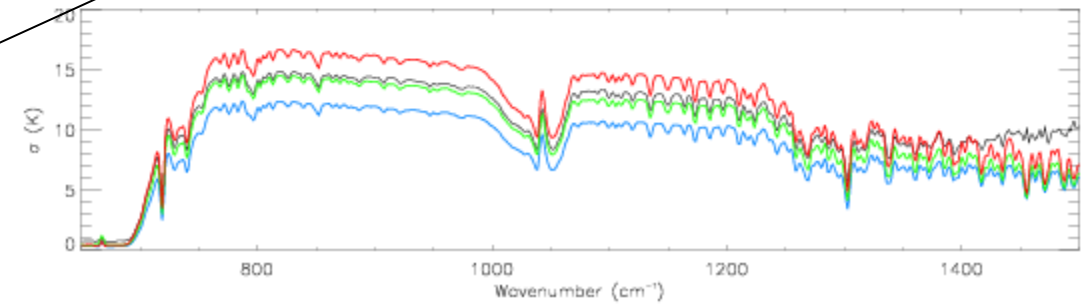


CO_2 increase (stratosphere)

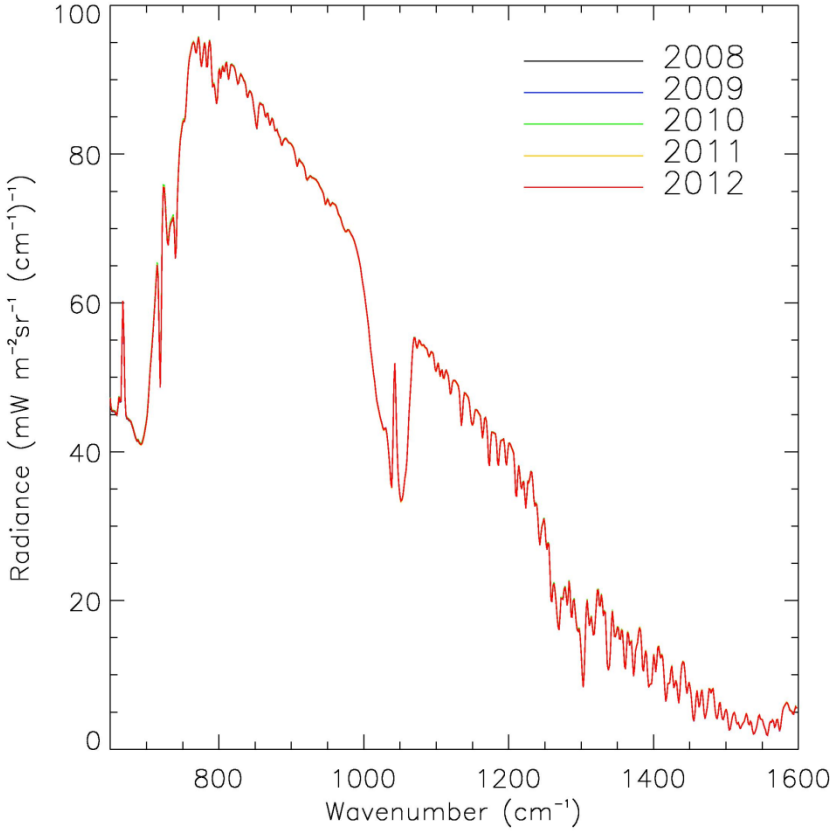


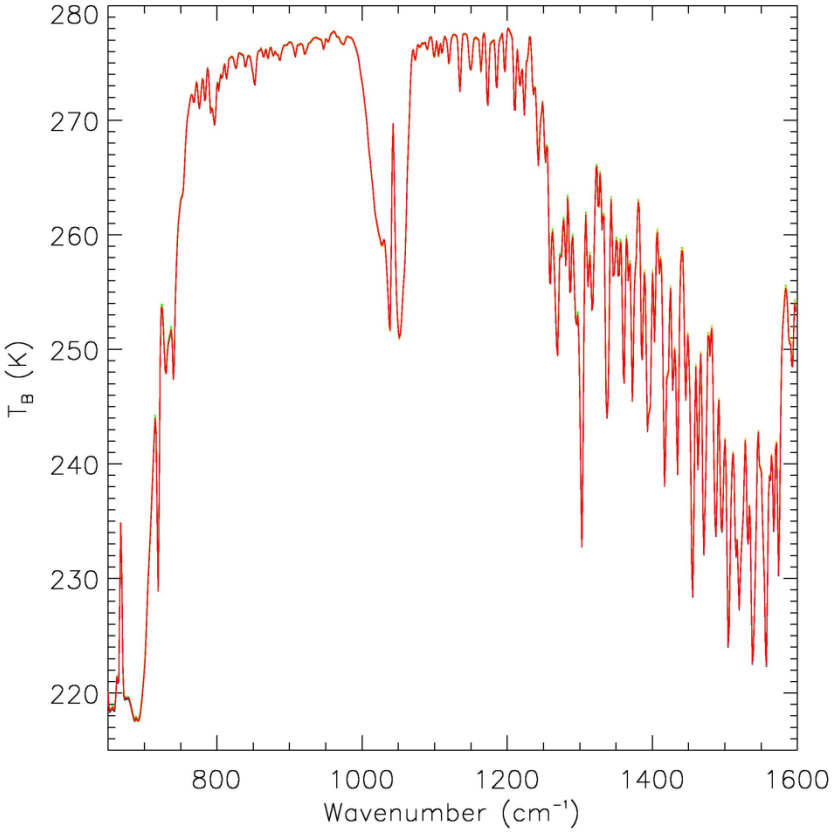
Robust CH_4 signal

Ordering of window signal consistent with ENSO phase differences



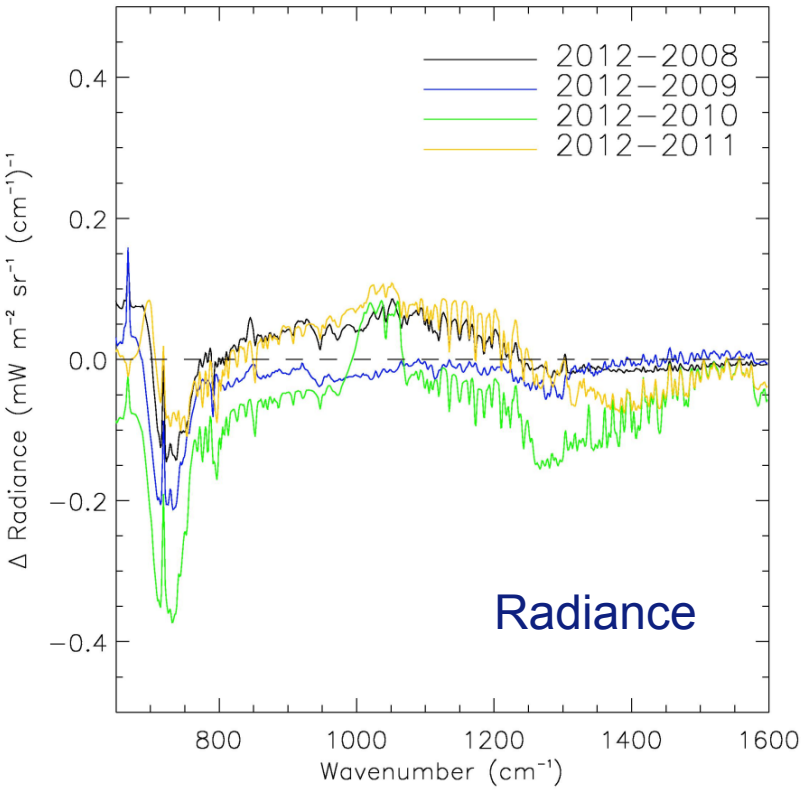
All-sky global annual means ('IRIS-like' IASI)

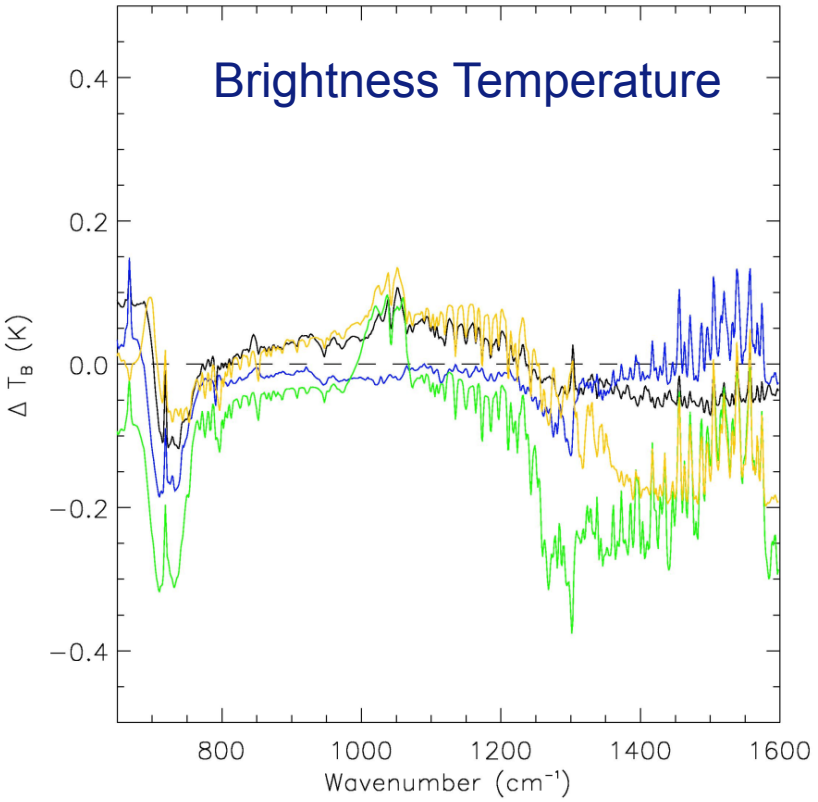




50 Tb data: approx 1 month to read 1 year (L1C)

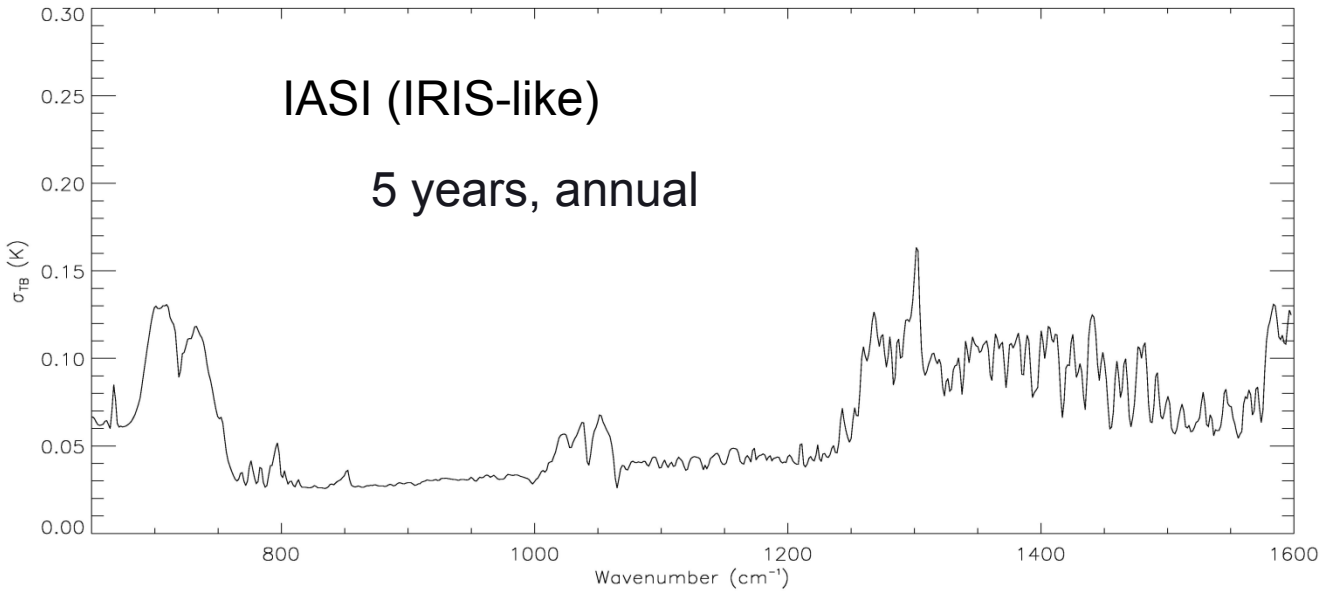
Differences relative to 2012

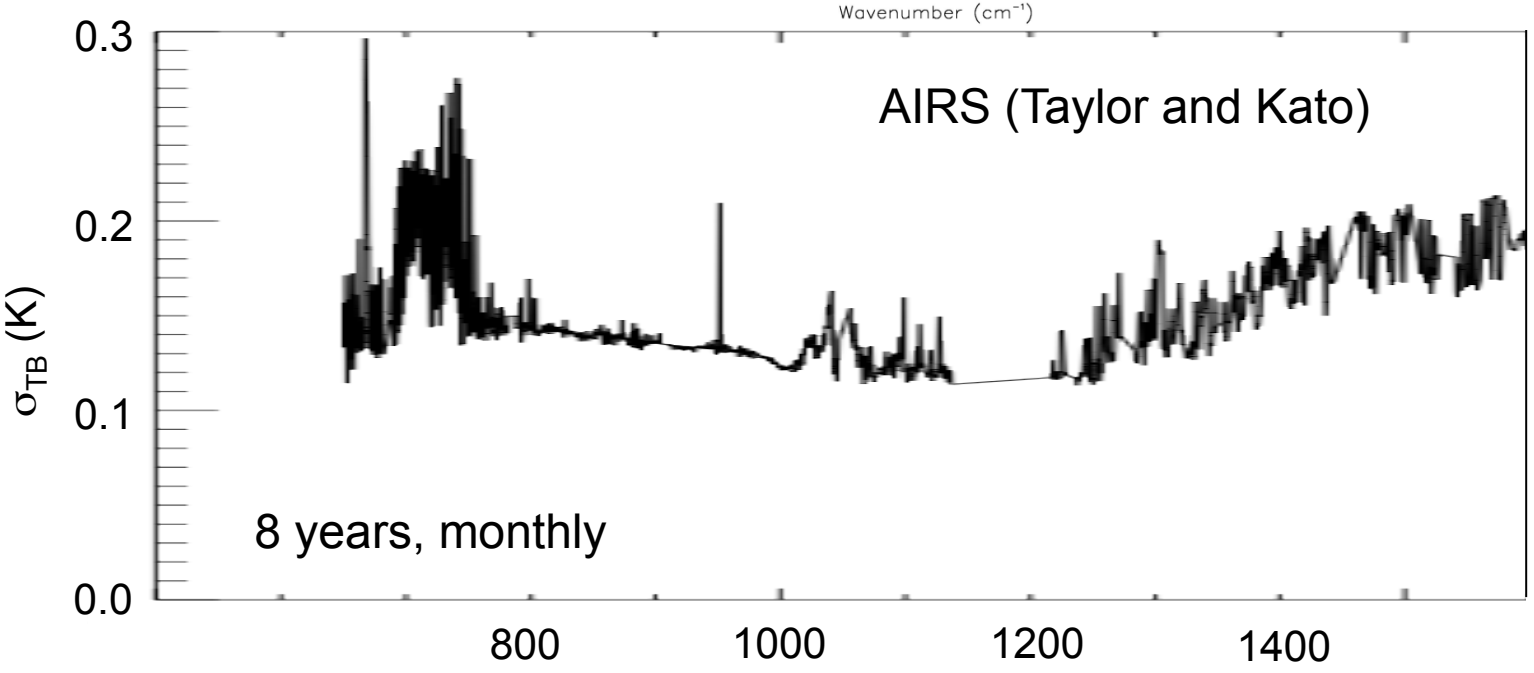




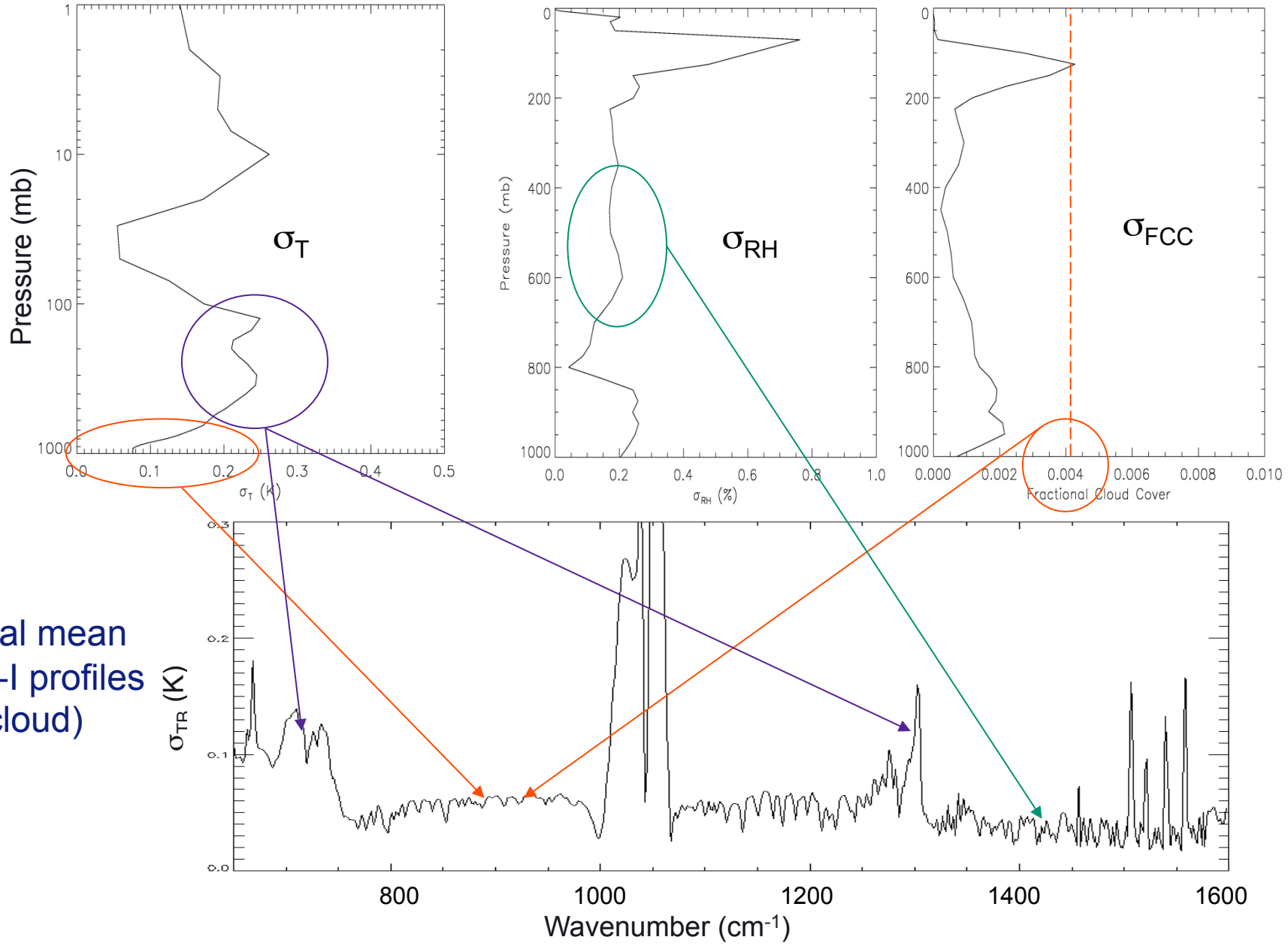
Max inter-annual variability in spectrally integrated IASI radiances ~ 0.3 %
Same order of magnitude seen in OLR variability from CERES over the same period (~ 0.2 %, note that yearly ranking is not the same)
Maximum variation at a given wavenumber ~ 1 %

Global Mean standard deviation - observations



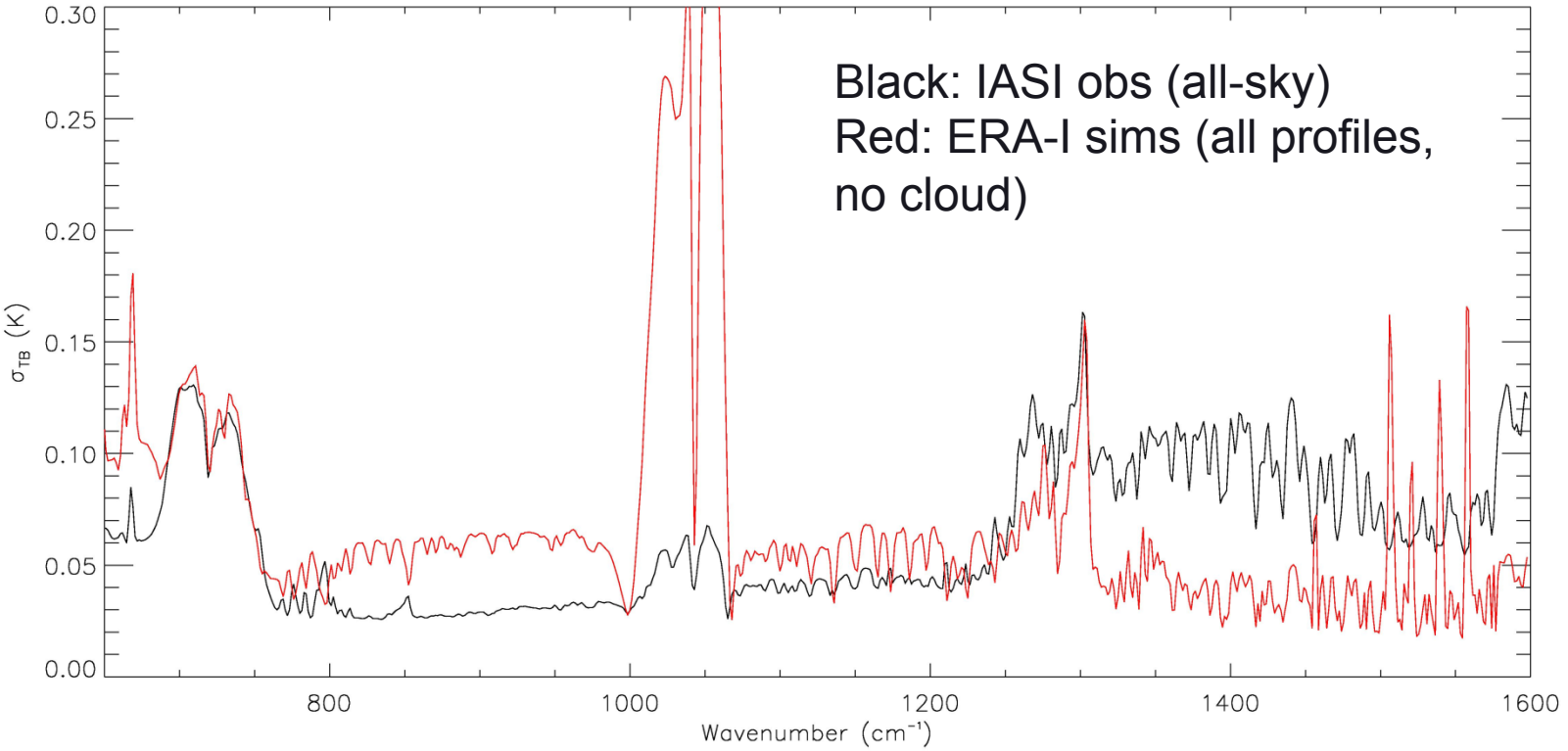


Global Mean standard deviation - simulations



NB:
Global mean
ERA-I profiles
(no cloud)

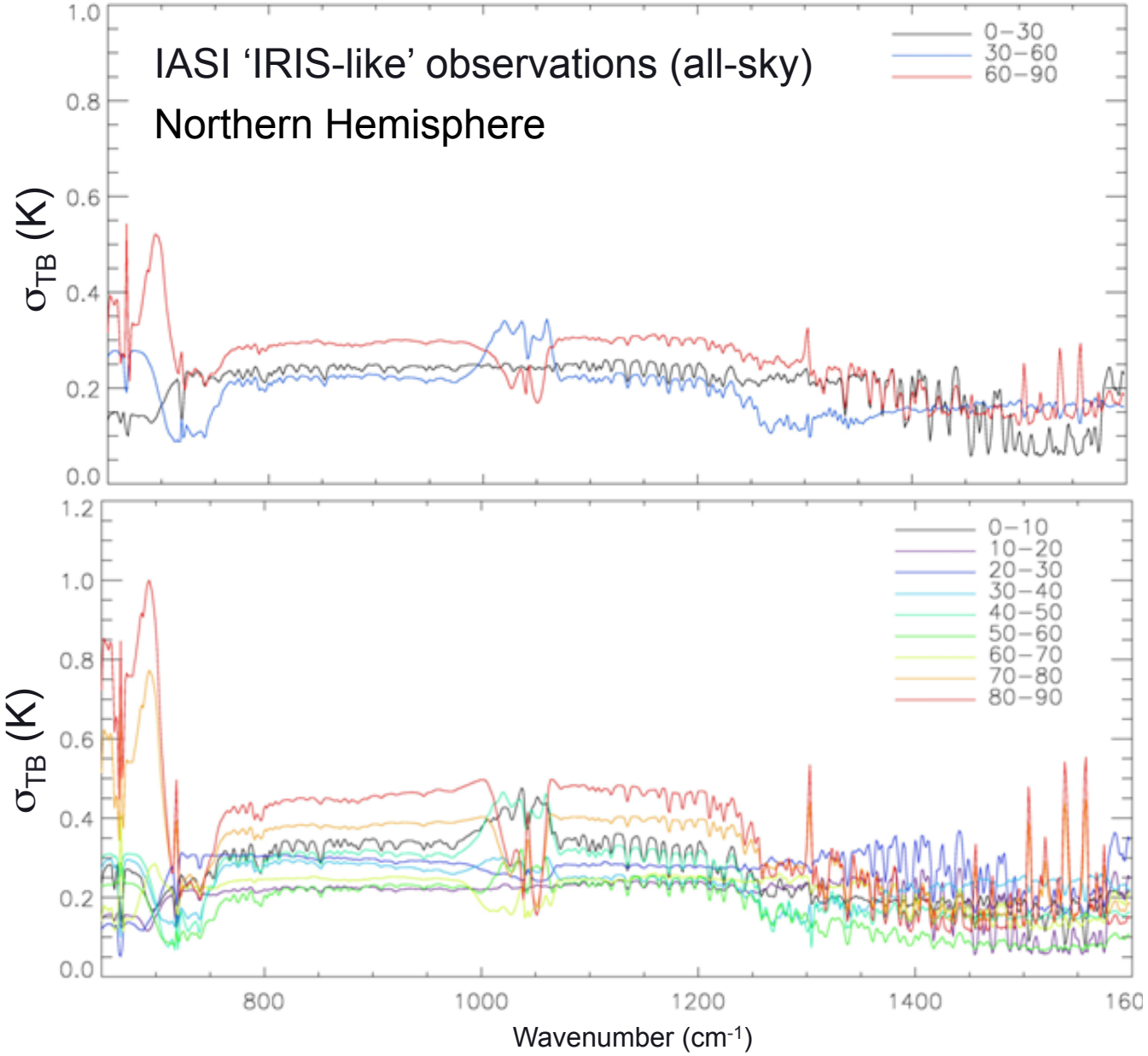
Global Mean standard deviation - comparison



Suggests:

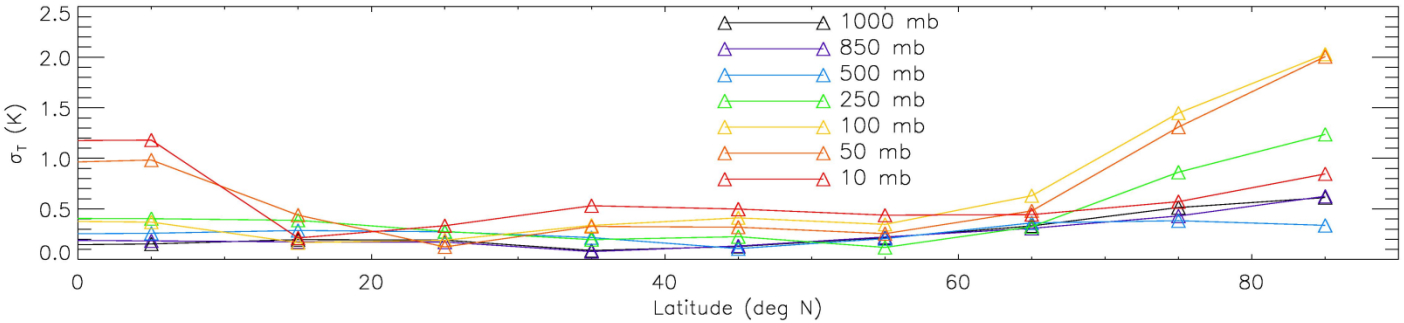
- 'Explicit' cloud damps variability at the global scale
- UT temperature variability well captured in ERA-I
- Absolute UT H_2O variability underestimated (NB – non-linearity issue)
- Stratospheric variability poorly captured
- Needs PCTRM or similar plus cloud fields for full analysis

Going to smaller spatial scales

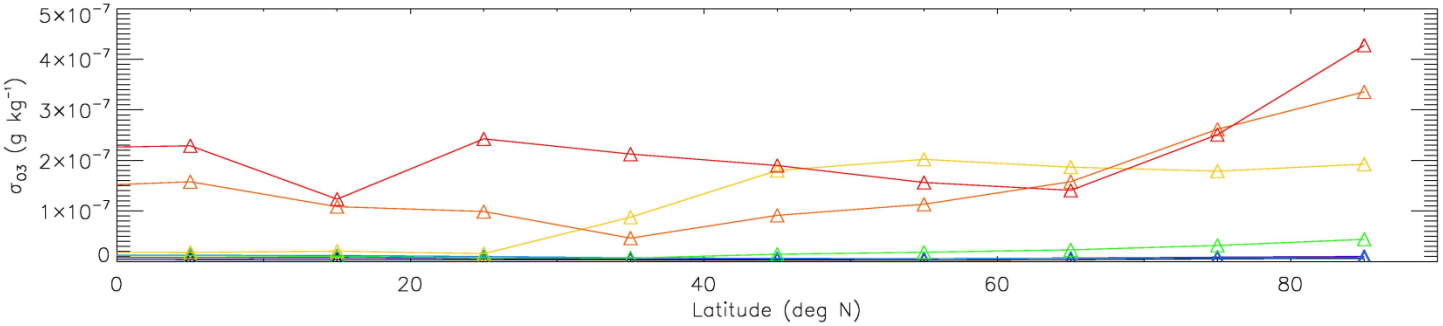


ERA-I annual variability

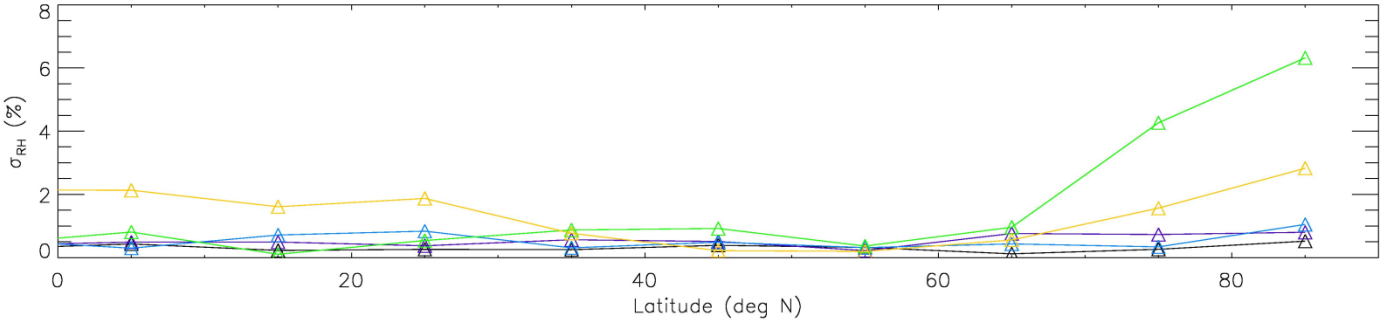
Temperature



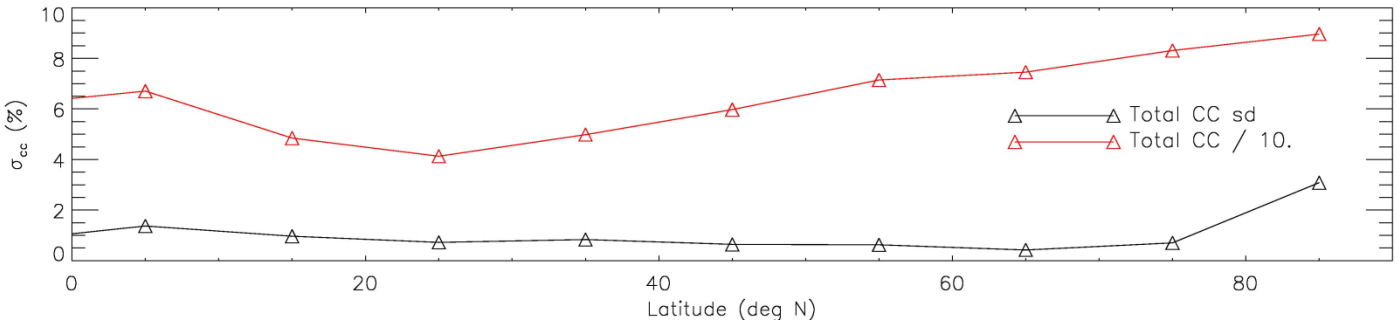
Ozone



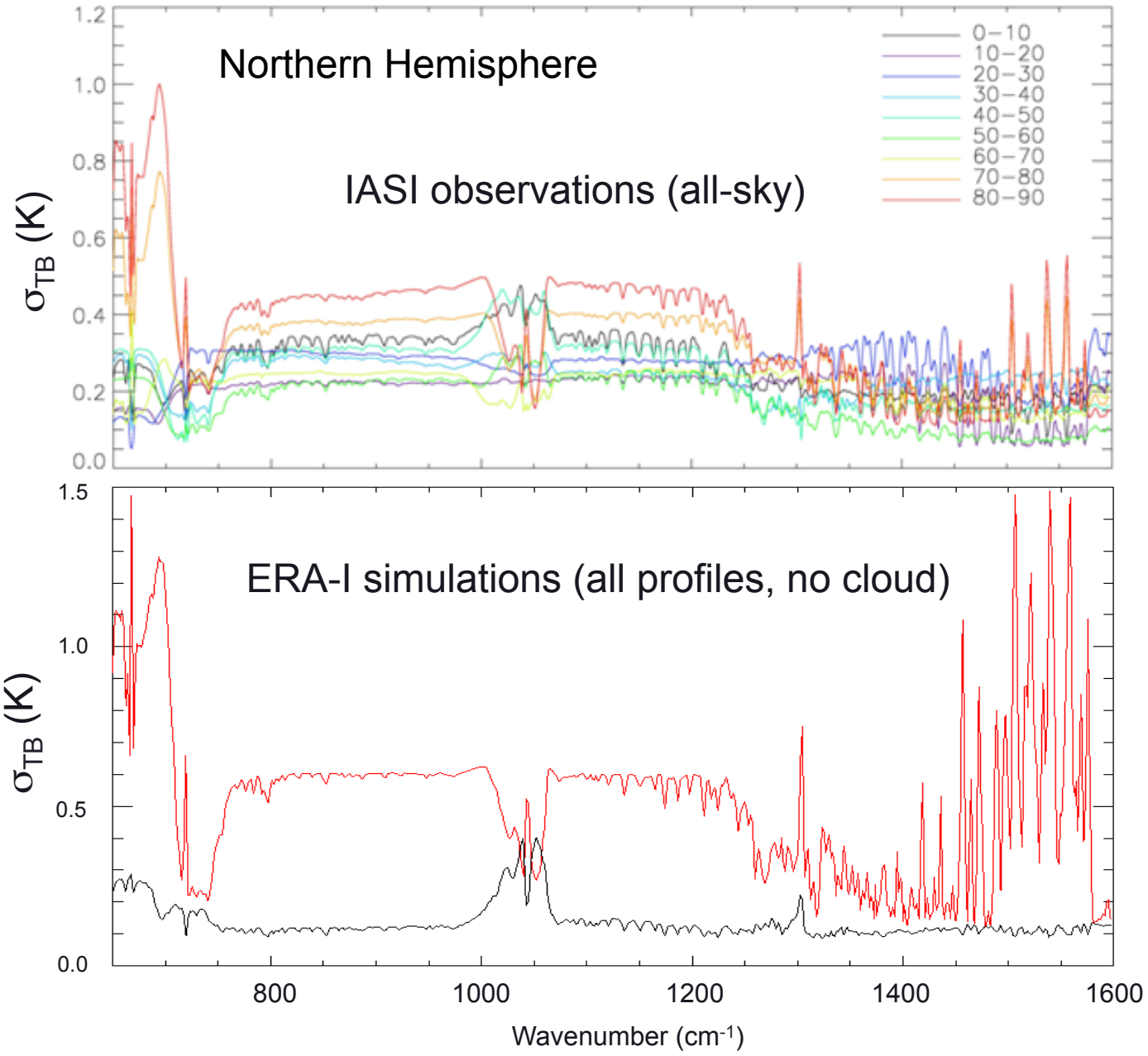
Relative Humidity



Total cloud cover



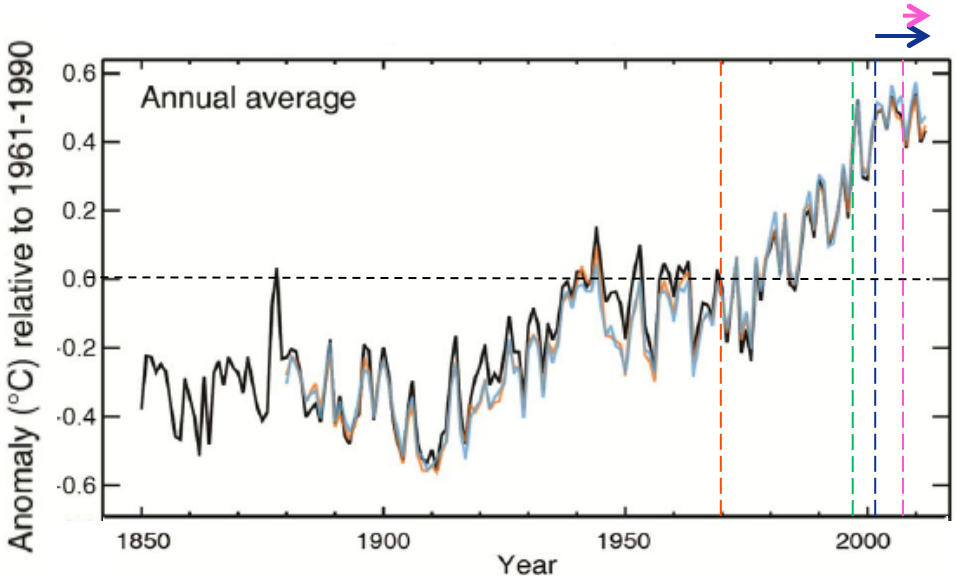
Going to smaller spatial scales

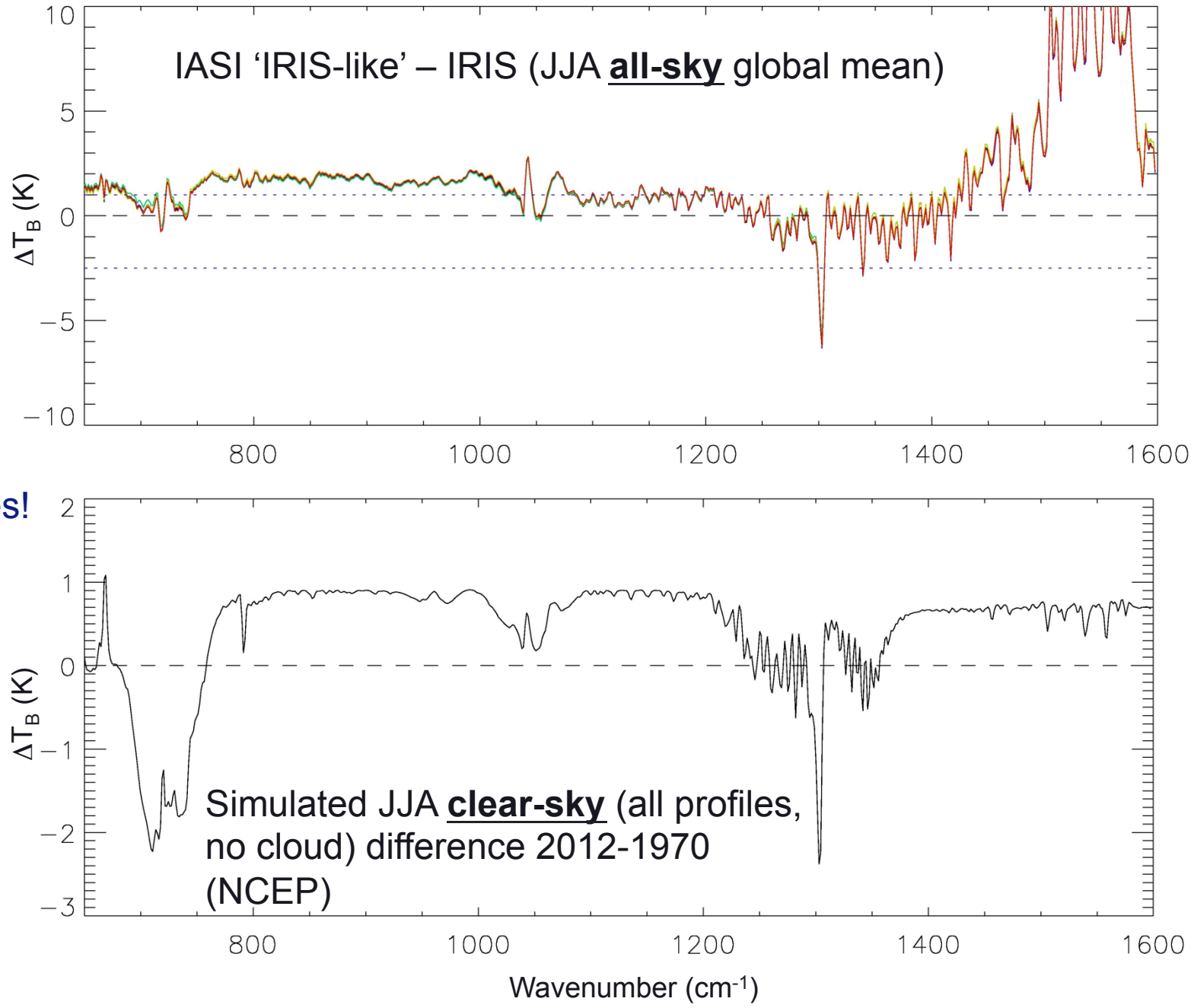


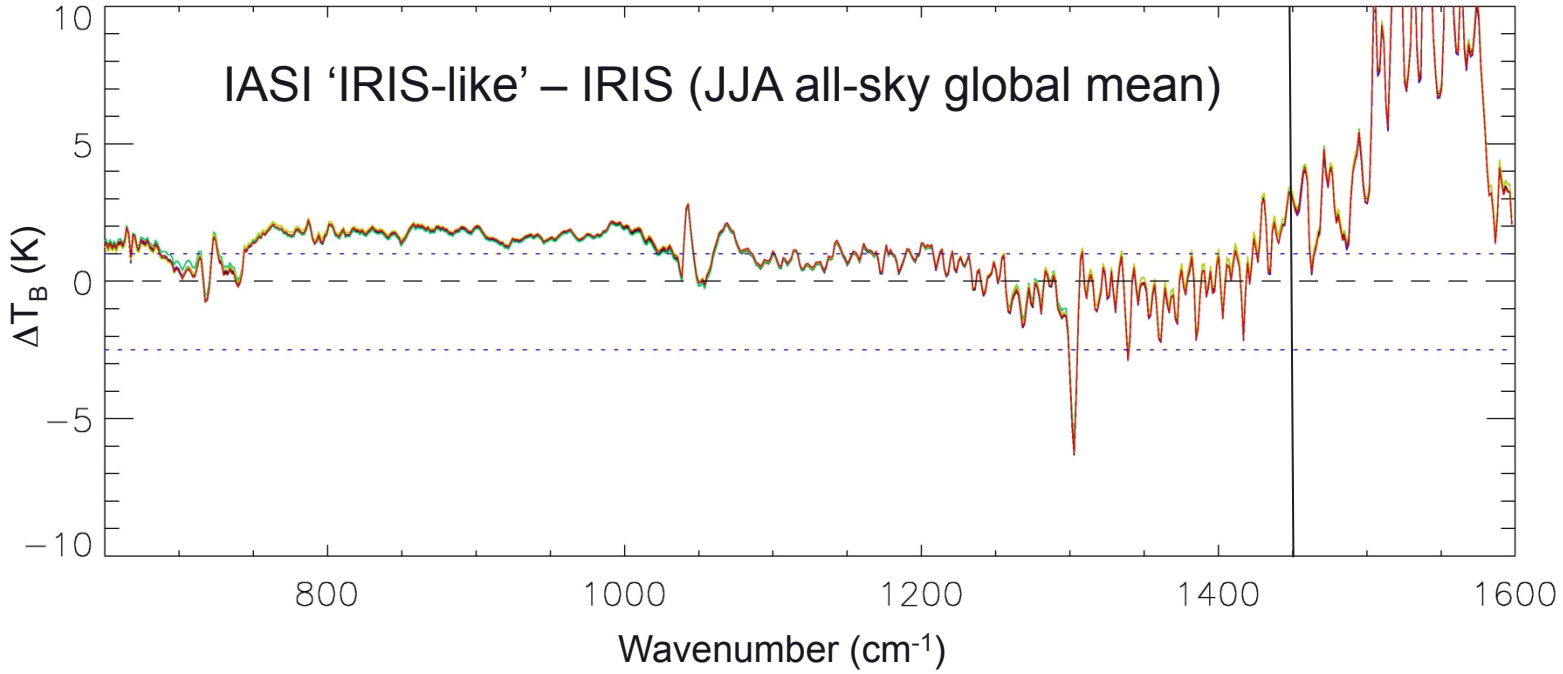
Variability: Conclusions

- At IRIS spectral scale, inter-annual global mean variability is extremely small (window < 0.05 K; max in regions sensitive to UT temperature (~0.1-0.15 K)
- Inter-annual variability increases with reducing spatial scale
- Initial comparisons indicate that cloud damps variability at the global scale; more complicated effects locally

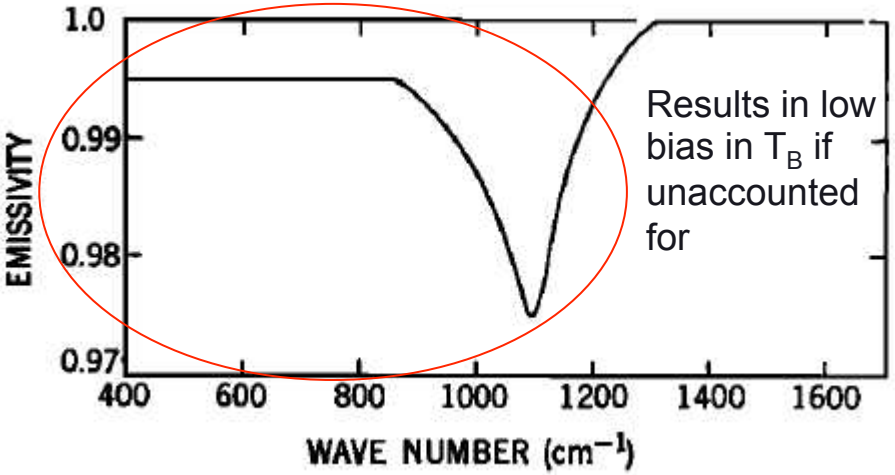
Results suggest that robust changes across the spectrum between IASI and IRIS should be possible to detect at the global scale given adequate instrument performance

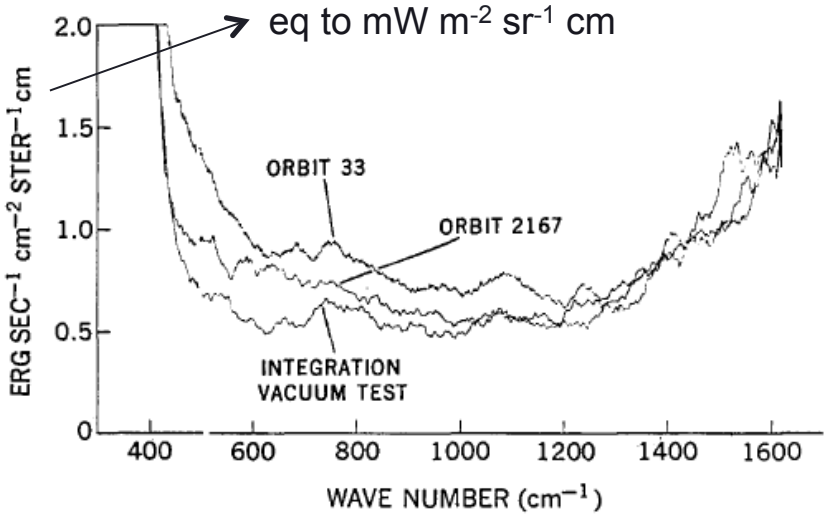



IASI 'IRIS-like' – IRIS (JJA all-sky global mean)
ΔT_B (K)
10
5
0
−5
−10
800
1000
1200
1400
1600
Note scales!
Simulated JJA clear-sky (all profiles, no cloud) difference 2012-1970 (NCEP)
ΔT_B (K)
2
1
0
−1
−2
−3
800
1000
1200
1400
1600
Wavenumber (cm-1)



Hanel *et al*., 1971, 1972

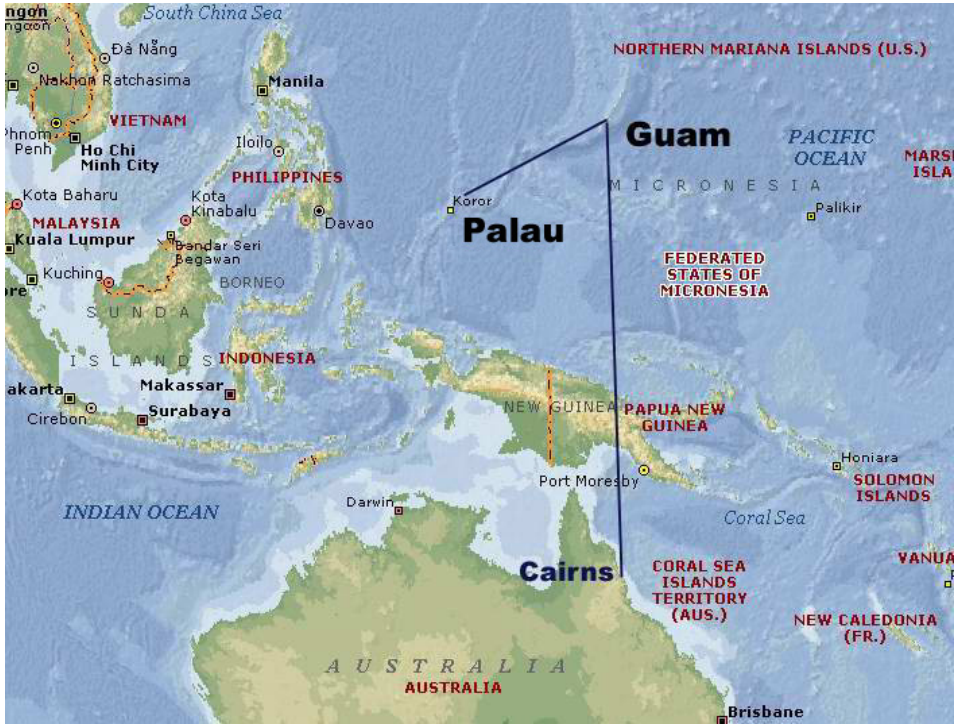




Quality assessment: IRIS spectra

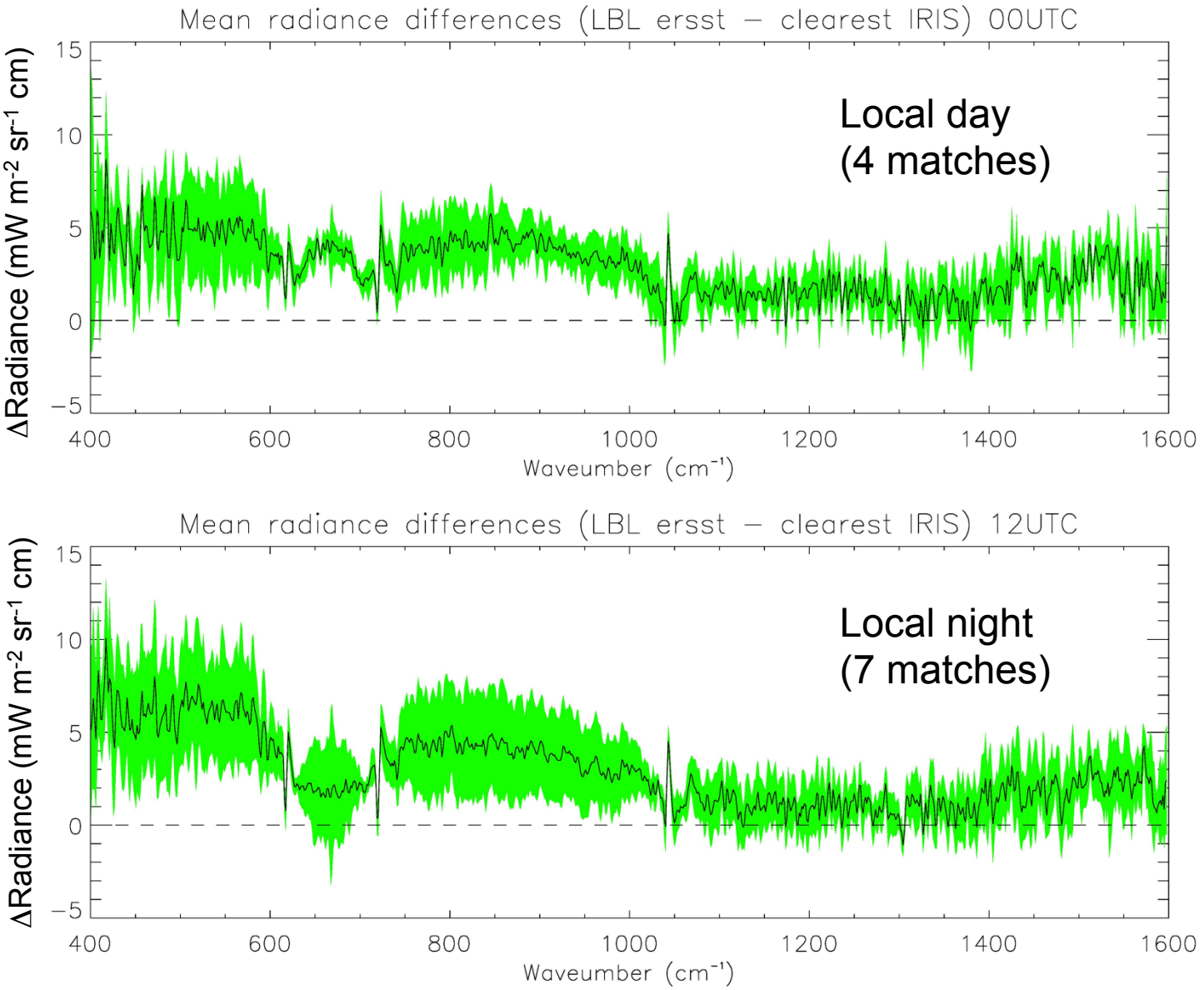
Main issue: reliability of atmospheric/surface data in 1970

- Radiosonde archives do exist (e.g. IGRA) but humidity data before 1971 is removed. Obtained non-archive data for Guam (courtesy M. Iacono). Known issues with low level humidity through 1970
- SST (or better skin temperature) data is of unknown quality. Monthly mean fields seem to be the highest resolution available: ERSST v3b



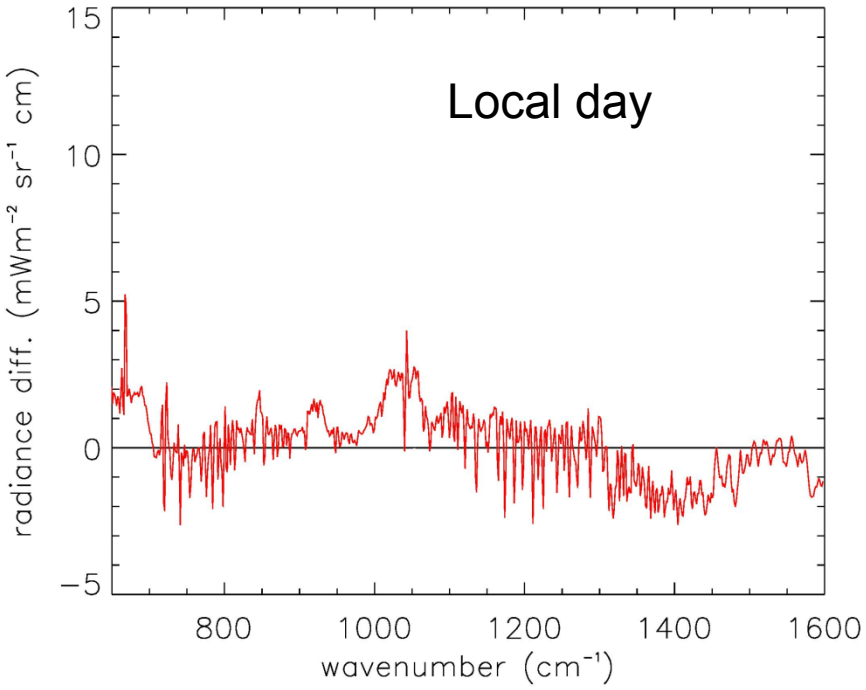
http://beyondthesunset.us/guam.htm

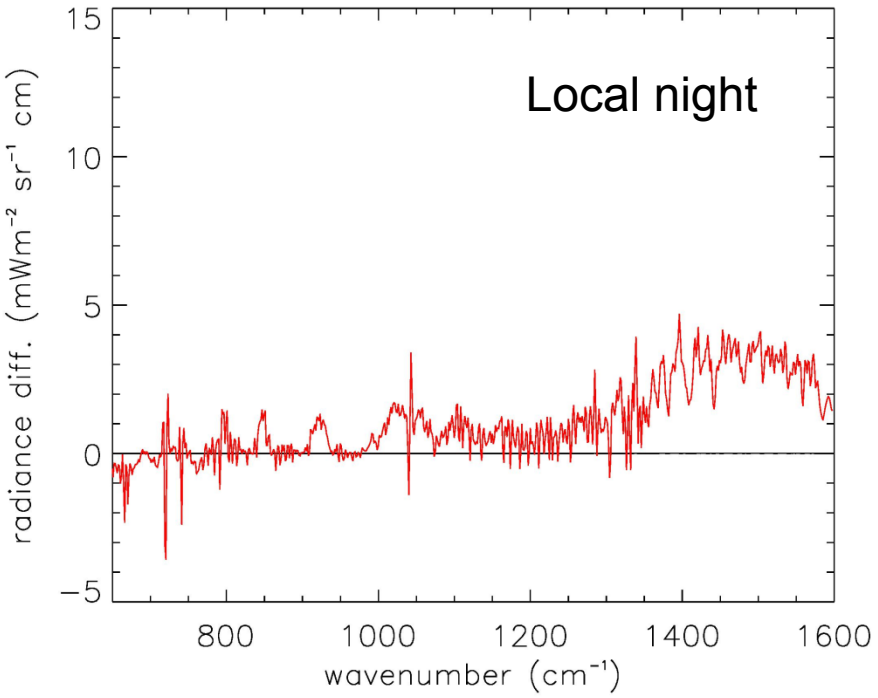
Quality assessment: Guam clear-sky cases (IRIS)



Quality assessment: Guam clear-sky cases (IASI)

June 5th, 2008





Monthly mean SST (K)		σ (K)
ECMWF Op 00 UTC	302.64	0.26
ECMWF Op 12 UTC	302.64	0.25
ERSST v3b	302.53	-

Change: conclusions

- Low level of inter-annual variability manifested in IASI spectra indicates that in principle, signatures of climate forcings and feedbacks could be identified in long-term differences
- Differences seen have a (mainly) consistent shape but seem too large to be realistic. Likely a result of sub-optimal calibration corrections applied to older data and floating calibration source
- Work ongoing to see if uncertainties can be quantified/attributed and potentially corrected for. Difficult due to quality of in-situ data

- Note that a CLARREO type instrument in orbit in previous decades (and now!) would have already addressed many of these issues